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Marine Algae of Kuei-Shan Dao, Taiwan

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ABSTRACT: The marine algae collected from Kuei-Shan Dao were identified and listed. A total of 75 species of seaweed, including 2 species of Cyanophyta, 19 of Chlorophyta, 12 of Phaeophyta, and 42 of Rhodophyta, were reported for the first time in this area. Among them, 2 species are new records for the marine flora of Taiwan, 6 species show the extension range in the known phytogeographic patterns. Most of algae in Kuei-Shan Dao are of tropical or subtropical elements. The effects of current on the distribution of algae and the floristic affinity of this island are also discussed.

KEY WORDS: Marine algal flora, New record, Phytogeography, Kuei-Shan Dao, Taiwan.

INTRODUCTION

Kuei-Shan Dao is a small island located about 10 km off seashore of northeastern Taiwan. It has a coastline of approximately 8.7 km and an area of about 2.9 km^2 (Fig. 1). It is a volcanic island, turtle-shape characterized by a 398 m maximum elevation on the northeastern side. Well-developed rocky reefs line the northeastern and southwestern shores. The prevailing northeast wind blows strongly in winter and the warm Kuroshio Current passes northward through this area in summer (Chu, 1971).

The marine algal flora of Taiwan has been studied by several workers (Yamada, 1925a, b, 1936, 1950; Okamura, 1931, 1936; Shen and Fan, 1950; Fan, 1951; Chiang, 1960, 1962a, b, 1972, 1973a, b; Taniguti, 1976; Wang and Chiang, 1977; Chiang and Chou, 1980; Wang and Chen, 1980; Chen and Chiang, 1981a, b; Chou and Chiang, 1981; Yang 1981; Chiang and Chen, 1982, 1983; Yang and Chiang, 1982; Chiang and Wang, 1987; Lewis and Norris, 1987; Chen, 1991; Huang, 1990, 1991; Wang *et al.*, 1993; Wang and Chiang, 1993, 1994; Yang *et al.*, 1994; Huang, 1997, 1998). However, the seaweed flora of Kuei-Shan Dao is poorly known. There is no any publication dealing with the marine algae of this area in the past. This study provides extensive information about the floristic and biogeographic data on the benthic marine algae of Taiwan.

MATERIALS AND METHODS

Algal specimens were collected from the littoral and sublittoral zones of Kuei-Shan Dao (Fig. 1) during 27-29 May, 1997 and 25-27 July, 1997. Skin and SCUBA diving equipment

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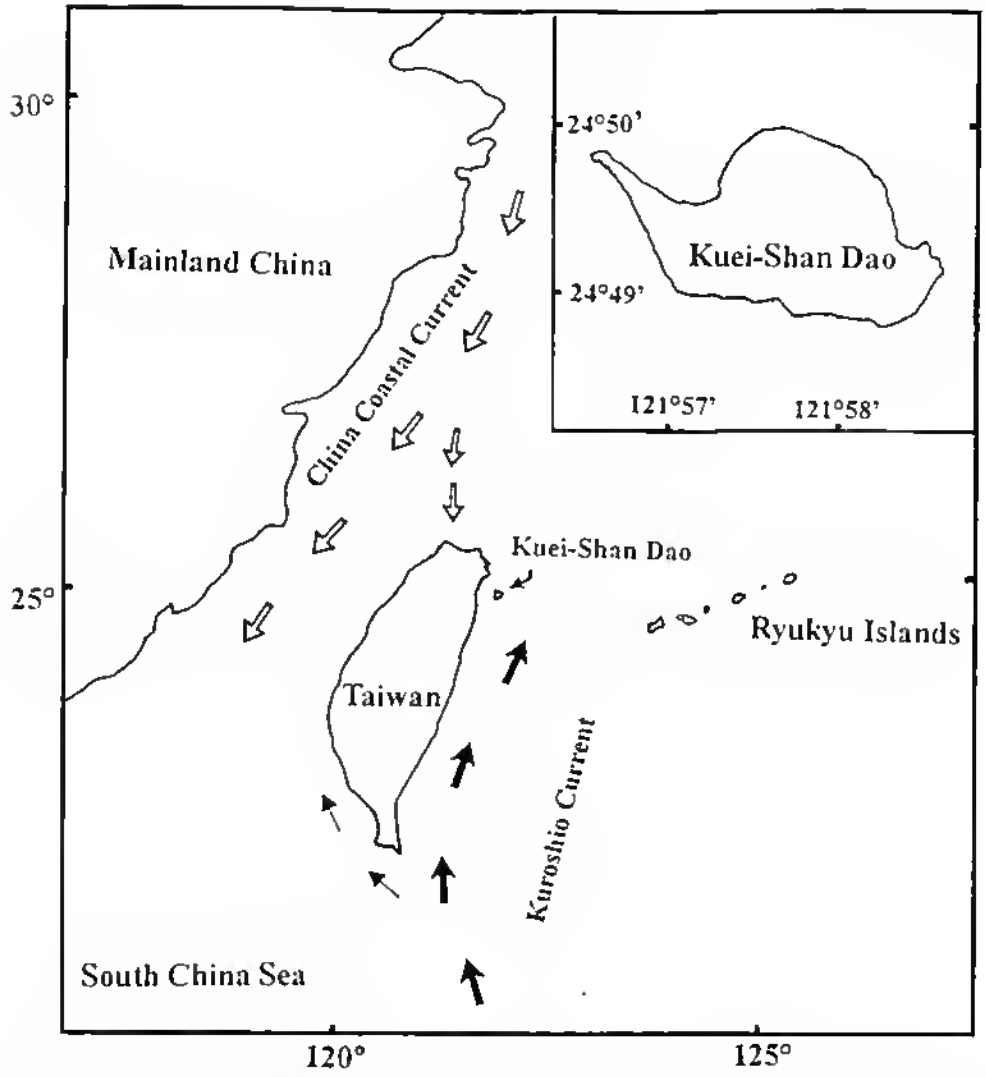

Fig. 1. Map showing geographic position of Kuei-Shan Dao and the adjacent currents.

were used for underwater collections and surveys. Specimens were either dried and mounted, or preserved in 10% formalin seawater. Liquid-preserved and dried herbarium specimens were used for this study. Sections were made by hand or with a freezing microtome. All voucher specimens are deposited in the Herbarium of Taiwan Museum.

RESULTS

There are a total of 75 species of marine algae identified in this study. They belong to 56 genera and 34 families, and include 2 species of Cyanophyta, 19 species of Chlorophyta, 12 species of Phaeophyta, and 42 species of Rhodophyta (Table 1). They are all reported for the first time from Kuei-Shan Dao. Among them, *Dictyota friabilis* Setchell (Figs. 2, 3, 4) and *Halymenia dilatata* Zanardini (Figs. 5, 6) are new records (∗) for Taiwan. Five species are range extension (#) to the known phytogeographic patterns, such as *Symploca hydnoides, Dictyota cervicornis, Lobophora variegata, Asparagopsis taxiformis, Galaxaura marginata and Tricleocarpa fragilis,* which are previously found only in southern Taiwan.

The structure of algal communities was also analyzed. In general, the flora of the upper wave-washed regions (upper littoral regions) was dominated by green algae, such as *Enteromorpha* spp. and *Ulva* spp. In the middle littoral region, there was a mixture of *Ulva* spp., *Enteromorpha* spp., *Chaetomorpha* spp., *Boergesenia forbesii*, *Dictyosphaeria cavernosa*, *Hincksia mitchellae*, *Colpomenia sinuosa*, *Ishige okamurai*, and *Hypnea* spp. On the exposed rocked of the lower littoral region or subtidal fringe, the scattered patches of *Valoniopsis pachynema*, *Padina* spp., *Caulerpa* spp., *Amphiroa* spp., *Gelidium* spp., *Pterocladia* spp., *Grateloupia filicina*, *Prionitis ramosissima*, *Mastophora rosea*, *Hypnea* spp., *Ahnfeltiopsis flabelliformis* and *Sargassum* spp. In the sublittoral zone, there was a mixture of *Dictyota* spp., *Gelidium* spp., *Pterocladia* spp., *Caulerpa* spp., *Codium* spp., *Liagora* spp., *Dudresnaya japonica*, *Corallina pilulifera*, *Marginisporum aberrans*, *Eucheuma serra*, *Meristotheca papulosa*, *Champia parvula*, *Chondria armata*, *Laurencia* spp., *Sarcodia montagneana*, *Tricleocarpa fragilis*, etc. The orders of the floristic list of algae are arranged according to Bold and Wynne (1985), while families, genera and species are arranged alphabetically.

Table 1. Numbers of algal taxa during studying period in Kuei-Shan Dao.

Phylum	No. of Families	No. of Genera	No. of Species	No. of new records for Taiwan
Cyanopyta	1	2	2	0
Chlorophyta	9	12	19	0
Phaeophyta	5	10	12	1
Rhodophyta	19	32	42	1
Total	34	56	75	2

CHECKLIST OF SPECIES

＊: new record for Taiwan
＃: new distributional range for Taiwan

CYANOPHYTA

OSCILLATORIACEAE

Lyngbya majuscula (Dillwyn) Harvey

Chiang, 1962b; Magruder and Hunt, 1979; Tseng, 1983; Silva *et al.*, 1987; Wang and Chiang, 1993; Silva *et al.*, 1996.

Thalli widely expanded on upper to lower intertidal rocks.

Symploca hydnoides (Harvey) Kützing ＃

Magruder and Hunt, 1979; Chiang and Wang, 1987; Huang, 1990; Silva *et al*, 1987; Silva *et al*, 1996; Huang, 1998.

Growing on upper intertidal rocks. This species was previously found only in southern Taiwan.

Geographic distribution: Hawaii, Philippines, Indian Ocean.

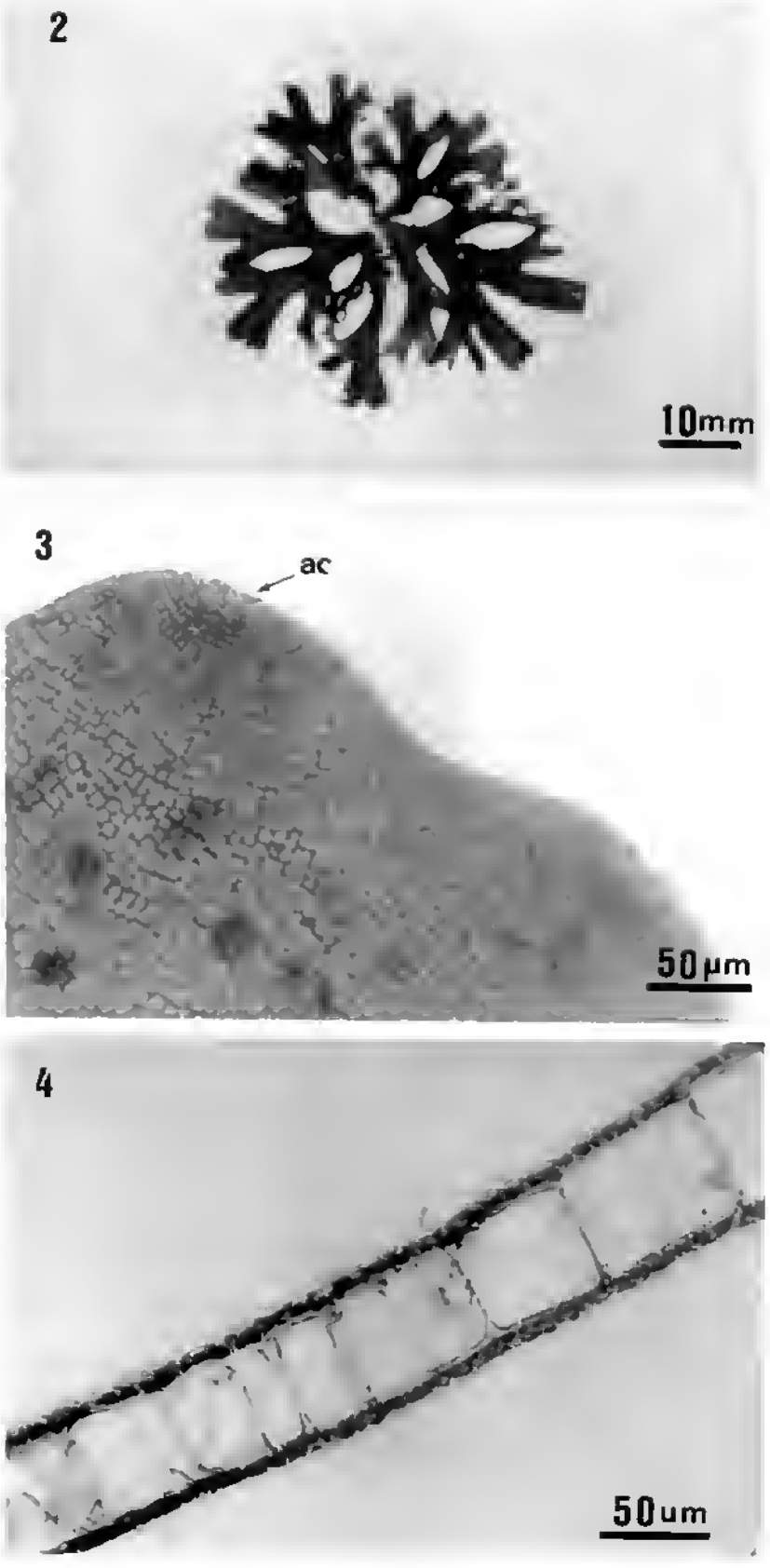

Fig. 2. Outline of *Dictyota friabilis*.
Fig. 3. Apical surface view of *Dictyota friabilis*, showing the apical cell (ac).
Fig. 4. Transverse section of the thallus of *Dictyota friabilis*.

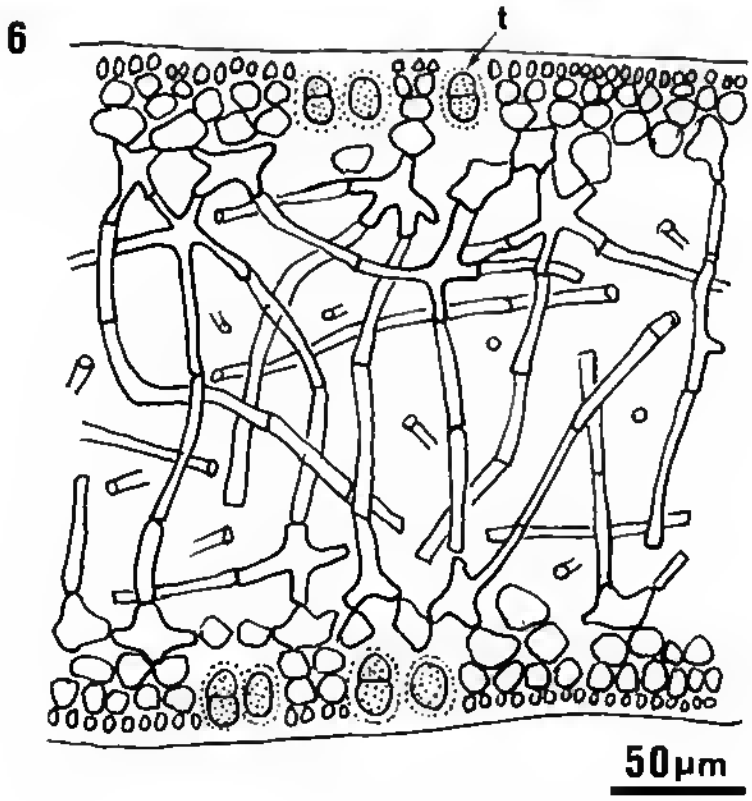

Fig. 5. Surface view of *Halymenia dilatata*.
Fig. 6. Transverse section of *Halymenia dilatata*, showing internal organization with tetrasporangia (t).

CHLOROPHYTA

ULVACEAE

Enteromorpha compressa (Linnaeus) Greville

Yamada, 1925a, 1950; Okamura, 1931, 1936; Shen and Fan, 1950; Chiang, 1960; Tseng, 1983; Silva *et al.*, 1987; Huang, 1990; Silva *et al.*, 1996; Huang, 1998.

Growing on middle to lower intertidal rocks.

Enteromorpha intestinalis (Linnaeus) Link *ex* Nees

Shen and Fan, 1950; Chiang, 1960, 1973b; Tseng, 1983; Silva *et al.*, 1987; Huang, 1990; Yoshida *et al.*, 1990; Silva *et al.*, 1996; Huang, 1998.

Growing on upper intertidal rocks.

Ulva conglobata Kjellman

Shen and Fan, 1950; Chiang, 1960, 1962a; Chiang and Wang, 1987; Tseng, 1983; Silva *et al.*, 1987; Huang, 1990; Silva *et al.*, 1996; Huang, 1998.

Growing on upper and middle intertidal rocks covered with sand.

Ulva fasciata Delile

Shen and Fan, 1950; Chiang, 1960, 1973b; Tseng, 1983; Silva *et al.*, 1987; Chiang and Wang, 1987; Huang, 1990; Silva *et al.*, 1996; Huang, 1998.

Growing on middle intertidal rocks and in rock pools.

Ulva lactuca Linnaeus

Okamura, 1930, 1931; Shen and Fan, 1950; Yamada, 1950; Chiang, 1960, 1973b; Tseng, 1983; Chiang and Wang, 1987; Silva *et al.*, 1987; Huang, 1990; Silva *et al.*, 1996; Huang, 1998.

Growing on middle intertidal rocks and in rock pools.

ANADYOMENACEAE

Anadyomene wrightii Harvey in Gray

Okamura, 1936; Shen and Fan, 1950; Chiang, 1973b; Tseng, 1983; Silva *et al.*, 1987; Chiang and Wang, 1987; Huang, 1990; Silva *et al.*, 1996; Huang, 1998.

Growing on subtidal rocks 0.5-1 m deep.

CLADOPHORACEAE

Chaetomorpha crassa (C. Agardh) Kützing

Yamada, 1925a, 1950; Okamura, 1931, 1936; Shen and Fan, 1950; Chiang, 1960, 1973b; Silva *et al.*, 1987; Chiang and Wang, 1987; Huang, 1990; Silva *et al.*, 1996; Huang, 1998.

Growing in shallow rock pools in the upper intertidal zone.

Chaetomorpha spiralis Okamura

Chiang, 1960, 1973b; Lewis and Norris, 1987; Silva *et al.*, 1987; Huang, 1990; Yoshida *et al.*, 1990; Silva *et al.*, 1996.

Growing on lower intertidal and subtidal rocks.

BOODLEACEAE

Boodlea composita (Harvey et Hooker) Brand

Okamura, 1936; Shen and Fan, 1950; Chiang, 1960, 1973b; Tseng, 1983; Silva *et al.*, 1987; Chiang and Wang, 1987; Huang, 1990; Silva *et al.*, 1996; Huang, 1998.

B. siamensis Reinbold
Yamada, 1925a; Okamura, 1931, 1936; Shen and Fan, 1950; Chiang, 1962b.

Thalli forming spongy masses on rocks in the lower intertidal and subtidal zone 0.5-1 m deep.

SIPHONOCLADACEAE

Boergesenia forbesii (Harvey) J. Feldmann

Chiang, 1962a, 1973b; Tseng, 1983; Silva *et al.*, 1987; Chiang and Wang, 1987; Yoshida *et al.*, 1990; Huang, 1990; Silva *et al.*, 1996; Huang, 1998.

Growing on middle intertidal sandy bottoms of rock pools.

Cladophoropsis javanica (Kützing) P.C. Silva

Silva *et al.*, 1996.

Cladophoropsis zollingeri (Kützing) Boergesen
Shen and Fan, 1950; Chiang, 1960; Womersley and Bailey, 1970; Tseng, 1983; Chiang and Wang, 1987; Lewis and Norris, 1987; Silva *et al.*, 1987; Huang, 1990; Yoshida *et al.*, 1990.

Thalli forming dense clumps on somewhat muddy mid-lower intertidal rock, preferably by the sides of rock pools.

VALONIACEAE

Dictyosphaeria cavernosa (Forsskal) Boergesen

Shen and Fan, 1950; Chiang, 1960, 1973b; Tseng, 1983; Silva *et al.*, 1987; Chiang and Wang, 1987; Huang, 1990; Silva *et al.*, 1996; Huang, 1998.

Growing on middle and lower intertidal to subtidal rocks 1m deep.

Valoniopsis pachynema (Martens) Boergesen

Yamada, 1950; Shen and Fan, 1950; Chiang, 1960, 1973b; Tseng, 1983; Silva *et al.*, 1987; Chiang and Wang, 1987; Huang, 1990; Silva *et al.*, 1996.

Valonia confervoides Harvey *ex* J. Agardh
Okamura, 1931, 1936.

Growing on lower intertidal to subtidal rocks.

BRYOPSIDACEAE

Bryopsis plumosa (Hudson) C. Agardh

Okamura, 1936; Shen and Fan, 1950; Chiang, 1960; Tseng, 1983; Silva *et al.*, 1987; Yoshida *et al.*, 1990; Silva *et al.*, 1996.

Growing on lower intertidal rocks or in rock pools in sheltered places though often exposed to moderate surf.

CAULERPACEAE

Caulerpa racemosa (Forsskal) J. Agardh var. laete-virens (Montagne) Weber-van Bosse

Okamura, 1931, 1936; Shen and Fan, 1950; Chiang, 1960, 1973b; Silva et al., 1987; Chiang and Wang, 1987; Huang, 1990; Silva *et al.*, 1996; Huang, 1998.

Growing on middle intertidal rocks covered with sand.

Caulerpa peltata (Lamouroux) Weber-van Bosse

Okamura, 1931, 1936; Shen & Fan, 1950; Chiang, 1960, 1962b; Womersley & Bailey, 1970; Silva *et al.*, 1996; Phang, 1998.

C. racemosa (Forsskal) J. Agardh var. *peltata* (Lamouroux) Eubank
Lewis and Norris, 1987; Silva *et al.*, 1987; Yoshida *et al.*, 1990.
C. peltata Lamouroux var. *typica* Weber-van Bosse
Tseng, 1983; Chiang and Wang, 1987.

Growing on lower intertidal sandy rocks.

CODIACEAE

Codium arabicum Kützing

Okamura, 1936; Shen and Fan, 1950; Tseng, 1983; Silva *et al.*, 1987; Silva *et al.*, 1996; Huang, 1998.

C. adhaerens (Cabrera) C. Agardh
Okamura, 1936; Chiang, 1960, 1962b; Lewis and Norris, 1987.

Growing on lower intertidal rocks.

Codium contractum Kjellman

Ariga, 1919; Taniguti, 1976; Lewis and Norris, 1987; Silva *et al.*, 1987; Yang *et al.*, 1994; Silva *et al.*, 1996.

Growing on lower intertidal rocks.

Codium intricatum Okamura

Yamada, 1950; Shen and Fan, 1950; Chiang, 1962b, 1973b; Silva *et al.*, 1987; Chiang and Wang, 1987; Yoshida *et al.*, 1990; Huang, 1990, 1998.

Growing on lower intertidal rocks.

PHAEOPHYTA

ECTOCARPACEAE

Hineksia mitchellae (Harvey) P.C. Silva

Silva *et al.*, 1987; Yoshida *et al.*, 1990; Silva *et al.*, 1996.

Giffordia mitchelliae (Harvey) Hamel
Tseng, 1983; Lewis and Norris, 1987; Huang, 1990.
Ectpcarpus mitchelliae Harvey
Okamura, 1936; Shen and Fan, 1950; Chiang, 1960; Tseng, 1983.

Thalli attached on the lower intertidal rocks.

DICTYOTACEAE

Dictyopteris repens (Okamura) Boergesen

Tseng, 1983; Lewis and Norris, 1987; Silva *et al.*, 1987; Yoshida *et al.*, 1990; Huang, 1990, 1998.

Neurocarpus repens Okamura
Okamura, 1931, 1936; Shen and Fan, 1950.

Thalli creeping on the other marine algae in the lower intertidal rocks and subtidal region 1 m deep.

Dictyota cervicornis Kützing #

Tseng, 1983; Chiang and Wang, 1987; Silva *et al.*, 1987; Yoshida *et al.*, 1990; Huang, 1990; Silva *et al.*, 1996; Huang, 1998.

Thalli growing on lower intertidal rocks. This species was previously found only in southern Taiwan. It was common in the Indo-pacific region.

Dictyota friabilis Setchell * Figs. 2, 3, 4

Dawson, 1954b: 401, fig. 16a, b; Magruder and Hunt, 1979: 43; Tseng, 1983:194; Trono, 1997:109.

A small creeping plant, yellowish brown clumps with blue-green iridescent, dichotomously branching, the segments short, strap-shaped, 3-6 mm in breadth, the apical segment with rounded apex and a distinct apical cell.

It was found growing on other algae or rocky bottoms in shallow subtidal reefs exposed to moderate water movement.

Geographical distribution: Common in the tropics, such as Hawaii, Xisha Islands, Philippines, Malay Archipelago, Tahidi, Fiji, etc.

Collection: H-1342 (May 28, 1997).

Lobophora variegata (Lamouroux) Womersley #

Tseng, 1983; Chiang and Wang, 1987; Silva *et al.*, 1987; Yoshida *et al.*, 1990; Huang, 1990; Wang and Chiang, 1993; Silva *et al.*, 1996; Huang, 1998.

Growing on lower intertidal roeks. This speeies was previously found only in southern Taiwan.

Padina arborescens Holmes

Lewis and Norris, 1987; Silva *et al.*, 1987; Yoshida *et al.*, 1990.

Growing in the subtidal zone 2-10 m deep.

Padina minor Yamada

Okamura, 1931, 1936; Shen and Fan, 1950; Chiang, 1960, 1962a, b, 1973b; Chiang and Wang, 1987; Tseng, 1983; Silva *et al.*, 1987; Wang and Chiang, 1993; Huang, 1990, 1998.

Growing on lower intertidal to subtidal roeks.

ISHIGEACEAE

Ishige okamurai Yendo

Okamura, 1936; Shen and Fan, 1950; Chiang, 1960, 1973b; Tseng, 1983; Lewis and Norris, 1987; Yoshida *et al.*, 1990.

Thalli growing on intertidal roeks.

SCYTOSIPHONACEAE

Colpomenia sinuosa (Mertens ex Roth) Derbes et Solier in Castagne

Okamura, 1930; Shen and Fan, 1950; Chiang, 1960; Tseng, 1983; Silva *et al.*, 1987; Yoshida *et al.*, 1990; Huang, 1990; Silva *et al.*, 1996; Huang, 1998.

Thalli growing on lower intertidal rocks.

Endarachne binghamiae J. Agardh

Yamada, 1925b; Okamura, 1930, 1936; Shen and Fan, 1950; Chiang, 1960, 1973b; Tseng, 1983; Yoshida *et al.*, 1990.

Thalli growing on middle and lower intertidal roeks.

Hydroclathrus clathratus (Bory) Howe

Okamura, 1936; Shen and Fan, 1950; Yamada, 1950; Chiang, 1960, 1962a, 1973b; Tseng, 1983; Chiang and Wang, 1987; Silva *et al.*, 1987; Huang, 1990; Silva *et al.*, 1996; Huang, 1998.

Growing on lower intertidal and subtidal roeks.

SARGASSACEAE

Sargassum cristaefolium C. Agardh

Okamura, 1931, 1936; Shen and Fan, 1950; Chou and Chiang, 1981; Chiang and Wang, 1987; Silva *et al.*, 1987; Huang, 1990; Silva *et al.*, 1996.

Growing on lower intertidal and subtidal roeks.

RHODOPHYTA

DERMONEMATACEAE

Dermonema virens (J. Agardh) Pedroche & Vila Orth
Silva *et al.*, 1996.

D. frappieri (Montagne *et* Millardet) Boergesen
Dawson, 1954b; Womersley and Bailey, 1970; Chiang, 1973b; Tseng, 1983; Silva *et al.*, 1987; Yoshida *et al.*, 1990; Wang and Chiang, 1993; Huang, 1998.
D. dichotomum Heydrich
Chen and Chiang, 1982.
D. gracilis Martens *ex* Weber-van Bosse
Okamura, 1931, 1936; Shen and Fan, 1950; Lewis and Norris, 1987.

Growing on exposed intertidal rocks.

HELMINTHOCLADIACEAE

Liagora ceranoides Lamouroux
Cordero, 1977b; Chen and Chiang, 1981a; Tseng, 1983; Chiang and Wang, 1987; Huang, 1990; Silva *et al.*, 1987; Yoshida *et al.*, 1990; Yang *et al.*, 1994; Silva *et al.*, 1996.
Growing in subtidal rocks.

Liagora orientalis J. Agardh
Okamura, 1936; Shen and Fan, 1950; Chiang and Chen, 1982; Silva *et al.*, 1987; Huang, 1990; Yoshida *et al.*, 1990; Silva *et al.*, 1996.
Growing on lower intertidal to subtidal rocks.

BONNEMAISONIACEAE

Asparagopsis taxiformis (Delile) Trevisan #
Tseng, 1983; Chiang and Wang, 1987; Silva *et al.*, 1987; Yoshida *et al.*, 1990; Huang, 1990; Silva *et al.*, 1996; Huang, 1998.

A. sanfordiana Harvey
Okamura, 1931, 1936; Shen and Fan, 1950.

Growing on lower intertidal to subtidal rocks. This species was previously found only in southern Taiwan. It was common in the tropics.

GALAXAURACEAE

Galaxaura marginata (Ellis et Solander) Lamouroux #
Papenfuss *et al.*, 1982; Lewis and Norris, 1987; Silva *et al.*, 1987; Huang, 1990; Silva *et al.*, 1996; Huang, 1998.

G. tenera Kjellman
Chiang, 1973a, 1973b; Chiang and Wang, 1987.
G. veprecula Kjellman
Papenfuss, 1968; Tseng, 1983.

Growing on subtidal rocks 1-3 m deep. This species was previously found only in southern Taiwan

Tricleocarpa fragilis (Linnaeus) Huisman et Townsend #

Huisman *et* Townsend, 1993; Silva *et al.*, 1996.

Galaxaura oblongata (Ellis *et* Solander) Lamouroux
Chiang, 1973a, 1973b; Papenfuss *et al.*, 1982; Tseng, 1983; Chiang and Wang, 1987; Silva *et al.*, 1987; Huang, 1990; Yoshida *et al.*, 1990.
Tricleocarpa oblongata (Ellis *et* Solander) Huisman *et* Borowitzka
Huisman *et* Borowitzka, 1990.

Growing on lower intertidal or subtidal rocks (1-5 m deep). This species was previously found only in southern Taiwan.

Scinaia moniliformis J. Agardh

Chiang, 1962a; Chiang and Wang, 1987; Silva *et al.*, 1987; Huang, 1990; Yoshida *et al.*, 1990; Wang and Chiang, 1993; Huang, 1998.
Growing on subtidal rocks 1-5 m deep.

GELIDIACEAE

Gelidium amansii (Lamouroux) Lamouroux

Okamura, 1913, 1930; Tseng, 1983; Lewis and Norris, 1987; Silva *et al.*, 1987; Silva *et al.*, 1996.

Gelidium elegans Kützing
Yoshida *et al.*, 1990.
G. amansii f. *elegans* Okamura
Fan, 1951; Chiang, 1962a; Lewis and Norris, 1987.

Growing on lower intertidal to subtidal rocks (10 m deep).

Pterocladia capillacea (S.G. Gmelin) Bornet

Silva *et al.*, 1987; Yoshida *et al.*, 1990; Silva *et al.*, 1996.

Pterocladia tenuis Okamura
Okamura, 1935b, 1936; Shen and Fan, 1950; Chiang, 1962a, b, 1973b; Tseng, 1983; Lewis and Norris, 1987.

Growing on intertidal to subtidal rocks (15 m deep).

DUMONTIACEAE

Dudresnaya japonica Okamura

Shen and Fan, 1950; Huang, 1990; Yoshida *et al.*, 1990.
Growing on the subtidal rocks (5-10 m deep).

HALYMENIACEAE

Carpopeltis maillardii (Montagne et Millardet) Chiang

Chiang and Wang, 1987; Silva *et al.*, 1987; Huang, 1990; Yoshida *et al.*, 1990; Wang and Chiang, 1993; Silva *et al.*, 1996; Huang, 1998.

C. rigida (Harvey *ex* J. Agardh) Schmitz
Shen and Fan, 1950.

Growing on lower intertidal to subtidal rocks (5 m deep).

Grateloupia filicina (Lamouroux) C. Agardh

Chiang, 1962a, 1973b; Tseng, 1983; Chiang and Wang, 1987; Silva *et al.*, 1987; Yoshida *et al.*, 1990; Silva *et al.*, 1996.

Growing on lower intertidal to subtidal rocks (2 m deep).

Halymenia dilatata Zanardini * Figs. 5, 6

Balakrishnan, 1961: 197; Cordero, 1977b: 109; Trono, 1997: 184.

Frond is gelatinous-membranous, 10-15 cm tall, attached by small scutate disc. In cross section of blade, cortical region has 3-5 layers of cells; outermost are paired and borne by an inner oblong-ovate cell, 4 μm broad or more. Medullary filaments are cylindrical, with stellate cells, arms to 4 μm broad. Tetrasporangia are embedded in the surface of the frond.

It was growing on the lower intertidal shaded areas or in upper subtidal zone exposed to moderate water movement.

Geographical distribution: Japan, Korea, Philippines, Solomon Islands, Indian, Somalia, South Africa, Sri Lanka, Tanzania.

Collection: H-1518 (May 29, 1997).

Halymenia microcarpa (Montagne) P. C. Silva

Silva *et al.*, 1987; Wang and Chiang, 1993; Silva *et al.*, 1996, Huang, 1998.

Halymenia ceylanica Harvey *ex* Kützing
Lewis and Norris, 1987.
Halymenia durvillaei Bory var. *ceylanica* (Harvey ex Kützing) Weber-van Bosse
Okamura, 1936; Shen and Fan, 1950; Chiang, 1962a; Chiang and Wang, 1987; Huang, 1990.

Growing on lower intertidal to subtidal rocks (10 m deep).

Prionitis ramosissima (Okamura) Kawaguchi

Kawaguchi, 1989; Yoshida *et al.*, 1990.

Grateloupia ramosissima Okamura
Shen and Fan, 1950; Chiang, 1962a, 1973a; Tseng, 1983; Silva *et al.*, 1987.

Growing on lower intertidal to subtidal rocks (5 m deep).

PEYSSONNELIACEAE

Peyssonnelia rubra (Greville) J. Agardh

Okamura, 1931, 1936; Shen and Fan, 1950; Tseng, 1983; Chiang and Wang, 1987; Silva *et al.*, 1987; Huang, 1990; Wang and Chiang, 1993; Silva *et al.*, 1996.

Peyssonnelia rubra (Greville) J. Agardh var. *orientalis* Weber-van Bosse
Cordero, 1977b; Dawson, 1954a.

Growing on subtidal rocks or old coral fragments (1-5 m deep).

Peyssonnelia distenta (Harvey) Yamada

Okamura, 1936; Shen and Fan, 1950; Chiang, 1962a, b; Chiang and Wang, 1987; Silva *et al.*, 1987; Yoshida *et al.*, 1990; Huang, 1998.

Growing on lower intertidal to subtidal rocks (5 m deep).

CORALLINACEAE

Amphiroa ephedraea (Lamouroux) Decaisne

Okamura, 1936; Shen and Fan, 1950; Silva *et al.*, 1987; Huang, 1990; Yoshida *et al.*, 1990; Yang *et al.*, 1994; Silva *et al.*, 1996.

Growing on lower intertidal to subtidal rocks (3 m deep).

Amphiroa fragilissima (Linnaeus) Lamouroux

Dawson, 1954a; Taylor, 1960; Cordero, 1977b; Tseng, 1983; Silva *et al.*, 1987; Yoshida *et al.*, 1990; Yang *et al.*, 1994; Silva *et al.*, 1996.

Growing on middle intertidal rocks.

Amphiroa pusilla Yendo

Okamura, 1936; Shen and Fan, 1950; Cordero, 1977b; Chiang and Wang, 1987; Yoshida *et al.*, 1990; Wang and Chiang, 1993.

Growing on lower intertidal rocks.

Cheilosporum acutilobum (Decaisne) Piccone

Yoshida *et al.*, 1990; Yang *et al.*, 1994; Silva *et al.*, 1996.

Cheilosporum jungermannioides Ruprecht *ex* J. E. Areschoug
Okamura, 1936; Shen and Fan, 1950; Tseng, 1983; Chiang and Wang, 1987; Lewis and Norris, 1987; Silva *et al.*, 1987; Huang, 1990.

Growing on lower intertidal to subtidal rocks (3 m deep).

Cheilosporum anceps (Kützing) Yendo

Okamura, 1936; Shen and Fan, 1950; Chiang and Wang, 1987; Huang, 1990; Yoshida *et al.*, 1990; Wang and Chiang, 1993.

Growing on lower intertidalt rocks.

Corallina pilulifera Postels et Ruprecht

Okamura, 1936; Chiang, 1962a; Tseng, 1983; Yoshida *et al.*, 1990.

Growing on lower intertidal to subtidal rocks (5 m deep).

Jania adhaerens Lamouroux

Shen and Fan, 1950; Chiang, 1962a, b; Tseng, 1983; Chiang and Wang, 1987; Huang, 1990; Yoshida *et al.*, 1990; Silva *et al.*, 1996; Huang, 1998.

Corallina decussata-dichotoma Yendo
Okamura, 1931, 1936.
Jania decussata-dichotoma (Yendo) Yendo
Okamura, 1936; Shen and Fan, 1950; Chiang, 1962a; Silva *et al.*, 1987.

Thalli are epiphytic on coarser algae or growing on roeks in lower intertidal zone.

Marginisporum aberrans (Yendo) Johansen et Chihara

Cordero, 1977b; Tseng, 1983; Yoshida *et al.*, 1990.

Amphiroa aberrans Yendo
Okamura, 1936.

Growing on lower intertidal roeks.

Mastophora rosea (C. Agardh) Setchell

Chiang, 1973; Tseng, 1983; Chiang and Wang, 1987; Silva *et al.*, 1987; Huang, 1990; Silva *et al.*, 1996; Huang, 1998.

M. macrocarpa Montagne
Okamura, 1931, 1936; Shen and Fan, 1950; Chiang, 1962a.

Growing on lower intertidal to subtidal rocks (5 m deep).

GIGARTINACEAE

Chondraeanthus intermedius (Suringar) Hommersand

Hommersand *et al.*, 1993; Yang *et al.*, 1994; Huang, 1998.

Gigartina intermedia Suringar
Shen and Fan, 1950; Chiang, 1962a; Tseng, 1983; Chiang and Wang, 1987; Yoshida *et al.*, 1990.

Growing on middle to lower intertidal roeks.

GRACILARIACEAE

Gracilaria vieillardii P. C. Silva

Silva *et al.*, 1987; Yoshida *et al.*, 1990; Silva *et al.*, 1996.

G. denticulata Kützing
Okamura, 1931, 1936; Chiang, 1962a; Yang and Chiang, 1982; Huang, 1990.

Growing on lower intertidal to subtidal roeks (5 m deep).

HYPNEACEAE

Hypnea eervieornis J. Agardh

Taylor, 1960; Dawson, 1961; Tseng, 1983; Chiang and Wang, 1987; Littler *et al.*, 1989; Huang, 1990; Yoshida *et al.*, 1990; Trono, 1997.

Growing on lower intertidal to subtidal rocks (5 m deep).

Hypnea japonica Tanaka

Shen and Fan, 1950; Chiang, 1962a; Tseng, 1983; Silva *et al.*, 1987; Yoshida *et al.*, 1990.

Growing on lower intertidal to subtidal rocks (10 m deep).

Hypnea pannosa J. Agardh

Okamura, 1936; Shen and Fan, 1950; Dawson, 1961; Tseng, 1983; Chiang and Wang, 1987; Huang, 1990; Silva *et al.*, 1996; Trono, 1997; Huang, 1998.

H. nidulans Setchell
Okamura, 1931, 1936; Shen and Fan, 1950.

Growing on lower intertidal to subtidal rocks (10 m deep).

PHYLLOPHORACEAE

Ahnfeltiopsis flabelliformis (Harvey) Masuda

Masuda, 1993; Wang and Chiang, 1993.

Gymnogongrus flabelliformis Harvey
Shen and Fan, 1950; Tseng, 1983; Yoshida *et al.*, 1990.

Growing on lower intertidal rocks or in rock pools.

RHIZOPHYLLIDACEAE

Portieria hornemannii (Lyngbye) Silva

Silva *et al.*, 1996; Trono, 1997; Huang, 1998.

Desmia hornemannii Lyngbye
Chiang, 1962a, 1973b.
Chondrococcus hornemannii (Mertens) Schmitz
Shen and Fan, 1950; Tseng, 1983; Chiang and Wang, 1987; Huang, 1990.

Growing on lower intertidal to subtidal rocks (5 m deep).

SARCODIACEAE

Sarcodia montagneana (J. Hooker et Harvey) J. Agardh

Silva *et al.*, 1996; Huang, 1998.

Sarcodia ceylanica Harvey *ex* Kützing
Shen and Fan, 1950; Chiang, 1962a; Chiang and Wang, 1987; Huang, 1990; Yoshida *et al.*, 1990.

Growing on middle intertidal to subtidal rocks (10 m deep).

SOLIERIACEAE

Eucheuma serra J. Agardh

Shen and Fan, 1950; Chiang, 1962a, 1973b; Chiang and Wang, 1987; Huang, 1990; Silva *et al.*, 1987; Silva *et al.*, 1996; Huang, 1998.

Growing on subtidal rocks (3-10 m deep).

Meristotheca papulosa (Montagne) J. Agardh

Okamura, 1936; Chiang, 1962a; Tseng, 1983; Chiang and Wang, 1987; Huang, 1990; Silva *et al.*, 1987; Silva *et al.*, 1996; Huang, 1998.

Growing on subtidal rocks (5-10 m deep).

CHAMPIACAEAE

Champia parvula (C. Agardh) Harvey

Okamura, 1931, 1936; Shen and Fan, 1950; Chiang, 1962a; Tseng, 1983; Chiang and Wang, 1987; Silva *et al.*, 1987; Huang, 1990; Silva *et al.*, 1996.

Growing on lower intertidal to subtidal rocks (1-2 m deep).

CERAMIACEAE

Centroceras clavulatum (C. Agardh) Montagne

Okamura, 1931, 1936; Shen and Fan, 1950; Chiang, 1962a, b; Tseng, 1983; Chiang and Wang, 1987; Huang, 1990; Silva *et al.*, 1987; Silva *et al.*, 1996; Huang, 1998.

Growing on lower intertidal to subtidal rocks (5 m deep).

RHODOMELACEAE

Chondria armata (Kützing) Okamura

Okamura, 1931, 1936; Shen and Fan, 1950; Chiang, 1962a, 1973b; Tseng, 1983; Chiang and Wang, 1987; Silva *et al.*, 1987; Huang, 1990; Silva *et al.*, 1996; Huang, 1998.

Growing on lower intertidal to subtidal rocks (10 m deep).

Laurencia brongniartii J. Agardh

Cordero, 1977b; Chiang and Wang, 1987; Silva *et al.*, 1987; Yoshida *et al.*, 1990; Silva *et al.*, 1996; Huang, 1998.

Growing on subtidal rocks (2-10 m deep).

Laurencia intermedia Yamada

Tseng, 1983; Chiang and Wang, 1987; Silva *et al.*, 1987; Huang, 1990; Yoshida *et al.*, 1990; Silva *et al.*, 1996.

Growing on lower intertidal to subtidal rocks (10 m deep).

Laurencia papillosa (C. Agardh) Greville

Okamura, 1931; Shen and Fan, 1950; Huang, 1990; Yoshida *et al.*, 1990; Silva *et al.*, 1996; Trono, 1997; Huang, 1998.

Growing on subtidal rocks (5 m deep).

DISCUSSION

In the records of seaweeds of Taiwan (Yamada, 1925a, b, 1936, 1950; Okamura, 1931, 1936; Shen and Fan, 1950; Fan, 1951; Chiang, 1960, 1962a, b, 1972, 1973a, b; Taniguti, 1976; Wang and Chiang, 1977; Chiang and Chou, 1980; Wang and Chen, 1980; Chen and Chiang, 1981a, b; Chou and Chiang, 1981; Yang 1981; Chiang and Chen, 1982, 1983; Yang and Chiang, 1982; Chiang and Wang, 1987; Lewis and Norris, 1987; Chen, 1991; Huang, 1990, 1991; Wang *et al.*, 1993; Wang and Chiang, 1993, 1994; Yang *et al.*, 1994; Huang, 1997, 1998), there are about 500 species of marine algae listed. There are 75 species of marine algae registered in this study. Among them, two species are new to Taiwan, and six species are new distributional range to Taiwan. Though Kuei-Shan Dao has an area of only 2.9 km^2, its marine algal flora is rather complicated.

Most of marine algae in Kuei-Shan Dao are red algae (56%). Other algae are green algae (25%), brown algae (16%), and blue algae (3%). Based on the (R+C)/P hypothesis of Cheney (Cheney, 1977; Wang and Chiang, 1993), the ratio of red and green to brown algae of Kuei-Shan Dao is 5.1, indicating a charaeteristic tropical nature. This agrees with the fact that most of algae in Kuei-Shan Dao are of tropical or subtropical species. Species such as *Symploca* sp., *Boergesenia forbesii, Caulerpa* spp., *Codium* spp., *Dictyota cervicornis, Lobophora variegata, Liagora* spp., *Galaxaura* spp., *Gracilaria* sp., *Cheilosporum* spp., *Asparagopsis taxiformis, Tricleocarpa fragilis* are widely distributied in tropical seas (Dawson, 1956; Kamura, 1963; Thoi, 1969; Silva, *et al.*, 1987; Silva, *et al.*, 1996; Callumpong and Menez, 1997; Trono, 1997; Critchley and Ohno, 1998). Especially, the occurrence of *Symploca hydnoides, Dictyota cervicornis, Lobophora variegata, Galaxaura marginata, Tricleocarpa fragilis,* and *Asparagopsis taxiformis* are found only in the southern Taiwan previously (Chiang and Chen, 1982; Chiang and Wang, 1987; Huang, 1990, 1998). They are never found in the northern Taiwan (Okamura, 1936; Chiang, 1960, 1962a, 1973a). It seems that the macroalgal distribution in Kuei-Shan Dao does not correlate with latitudinal change.

It is well known that water temperature and current seem to be the principal factors regulating the phytogeographical distribution of marine algae (Lobban *et al.*, 1985). Chiang (1973a) first pointed out that northern Taiwan flora was distinet from its southern counterpart due to the influence of the warm Kuroshio Current. The Kuroshio Current brings warm water from the Philippines and the equatorial region toward southern Taiwan (Chu 1963, 1971; Chern and Wang, 1990). The current along eastern coast of Taiwan in a NNE direction is the main flow of Kuroshio (Fig. 1). The Kuei-Shan Dao loeated on the way of Kuroshio. This is possibly the reason why it shares many tropical algal genera with southern Taiwan.

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龜山島海藻之研究

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摘　　要

本文為一九九七年間在臺灣東北部海域之龜山島進行海藻的採集及調查研究，共採了 75 種海藻，包括藍藻 2 種，綠藻 19 種，褐藻 12 種，紅藻 42 種。這些藻類皆為龜山島的首次記錄，其中有 2 種為臺灣地區的新記錄種，另外有 6 種則在海藻植物地理分佈上有擴張現象。在海藻組成上，龜山島具有印度－西太平洋特有之熱帶性海藻，有關洋流對本區海藻相之影響亦在本文中討論。

關鍵詞：海藻相，新記錄種，植物地理，龜山島，臺灣。

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